

**ILLUMINATION METHOD AND DEVICE FOR DETECTING SURFACE
DEFECTS AND/OR MATERIAL SHORTAGE
ON THE NECK RING OF A CONTAINER**

The present invention concerns the technical area of the optoelectrical
5 inspection of hollow objects or containers in general, that are preferably transparent
or translucent such as bottles, glass jars or flasks for example, for the purpose of
detecting any surface defects on the neck ring of such containers.

The purpose of the invention is more precisely to detect, at the neck ring of an
object, any surface defects or flaws corresponding to material shortage on the surface
10 called « unfilled finish ».

In the state of the art, a device is known to detect such defects comprising a
light source providing an incident light beam illuminating the surface of the neck
ring of a container. Said detection device also comprises a line scan camera
positioned to receive the light beam reflected by the neck ring of the container. The
15 presence of a defect disturbs light reflection which, depending upon the type of
defect, causes light extinction or flare detectable by the line scan camera which is
connected to an analysis and processing unit adapted for analysis the video signal
delivered by the camera in order to determine the presence or absence of a surface
defect and/or material shortage. With said device it is possible to detect unfilled
20 finishes in particular which relate to material shortage on the surface. An unfilled
finish corresponds to a hollow part in the surface of the neck ring which is normally
planar or rounded. Said defects can be seen in a dark or black image against a white
background.

To ensure proper inspection of the neck ring surface of containers, control must
25 be gained over the incident angle of the light flow with respect to the surface of the
neck ring. For small-sized neck rings such as those of bottles, this incident angle can
be controlled by changing the height of the light source as is proposed for example in
patent US 4 606 635 which describes a device for detecting defects on the neck ring
of a container. Said device comprises an annular light source delimited by an inner
30 cylinder and an outer cylinder defining between them a cylindrical outlet whose
height can be adjusted through relative movement of the cylinders. Relative
movement can be imparted to this light source with respect to the container to be
inspected so as to adjust the angle of incidence of the diffuse light beam.

This device is not adapted for detecting defects on neck rings having large size surface areas, in particular on account of the angle of incidence which is too small and does not allow uniform lighting of the ring surface to be obtained. Also, for containers having neck rings whose surface is slightly inclined inwards or outwards,
5 it proves to be insufficient to correct the angle of incidence solely by adjusting the height of the light source. Finally, it is to be noted that with said inspection device it is not possible to adapt to the different diameters of the neck rings found on containers to be inspected.

Also an apparatus is known through patent FR 2 596 523 for inspecting bottle
10 caps, comprising a divergent annular light source positioned above the cap to be inspected. This apparatus comprises a first optical mask defining the radiation range of the light source and a second optical mask defining the field of vision of a photoelectric sensor.

With this apparatus it is possible to detect a defect on the lower part of a cap on
15 a bottle neck. However, this apparatus is not adapted for detecting defects on the surface of the neck rings of containers which all have different slopes, widths and diameters. Also, with this apparatus it is not possible to achieve uniform illumination of containers having large surface areas.

Analysis of the state of the art leads to ascertaining that a technique is required
20 with which it is possible to control the angle of incidence and/or the width of a uniform light flow with respect to the neck ring surface of the containers, in order to adapt to the different slopes, widths and diameters of container neck rings.

The present invention therefore sets out to meet this need by proposing a method to detect surface defects and/or material shortage on the neck rings of various
25 containers having different slopes, widths and diameters.

To achieve this objective, the method of the invention to detect surface defects and/or material shortage, comprises the following steps:

- illuminating the surface of the container's neck ring with an incident light beam,
- collecting, via a line scan camera, the light beams reflected by the neck ring of the
30 container to determine the presence of any surface defect and/or material shortage.

According to the invention, the method consists of:

- obtaining a uniform ring of light converging towards a point of convergence located on the axis of symmetry of the container and having a variable diameter and/or variable width,
- and of selecting :
 - 5 – the diameter of the convergent uniform ring of light at a given value in relation to the desired mean angle of incidence to illuminate the surface of the neck ring of the container,
 - and/or the width of the convergent uniform ring of light at a given value in relation to the surface width of the neck ring of the
 - 10 container.

According to one characteristic of the invention, the method consists of:

- obtaining a uniform ring of light of variable diameter and/or variable expanse,
- ensuring the convergence of the ring of light at a point of convergence,
- 15 so as to illuminate the surface of the neck ring of the container with the convergent uniform light beam.

According to a first variant of embodiment, the method consists of:

- obtaining a ring of light, via a series of concentric elementary rings of light,
- 20 ▪ selectively commanding the switching on/off of the elementary rings of light to obtain a ring of light of determined diameter and/or determined width.

According to a second variant of embodiment, the method consists of :

- obtaining a ring of light whose diameter can be varied through relative
- 25 movement between a conical mirror and a planar annular light source emitting onto the conical mirror, perpendicular to the axis of said mirror,
- ensuring relative movement between the annular light source and the conical mirror along the axis of the conical mirror over a given height to obtain a ring of light of determined diameter.

- 30 According to an advantageous characteristic of the invention, the method consists of polarizing the incident light beam and of polarizing the reflected light beam before it is received by the camera.

A further objective of the invention is to propose an illumination device for a detection station detecting a neck ring surface defect and/or material shortage on a container having an axis of symmetry.

According to the invention, the illumination device comprises:

- 5 ▪ illumination means able to provide a uniform ring of light converging towards a point of convergence located on the axis of symmetry of the container and having a variable diameter and/or variable width,
- and means for creating a convergent uniform ring of light having a given diameter value in relation to the desired mean angle of incidence to
- 10 illuminate the surface of the neck ring of the container /and or a given width value in relation to the surface width of the neck ring of the container.

According to a preferred characteristic of embodiment, the illumination means comprise:

- 15 ▪ an illumination system able to provide a uniform ring of light of variable diameter and/or variable expanse,
- and an optical system for converging the ring of light onto a point of convergence so as to illuminate the neck ring surface of the container with the convergent uniform light beam.

20 According to a first variant of embodiment, the illumination system, providing a ring of light, consists of a series of elementary annular light sources mounted concentric fashion with respect to each other, while the means for creating a ring of light are formed by a selective on/off command unit for the elementary annular light sources.

25 According to a second variant of embodiment, the illumination system, providing a ring of light of variable diameter, consists of a conical mirror movably mounted with respect to a planar annular light source emitting onto the conical mirror perpendicular to the axis of said mirror, while the means for creating a ring of light of given diameter are formed by means commanding the relative movement of

30 the conical mirror and the planar annular light source, along the axis of the mirror and over a given height in order to obtain a ring of light of determined diameter.

According to another embodiment of the second variant of embodiment, the planar annular light source comprises an annular light source emitting in direction of

a light beam return cone, along a direction perpendicular to the axis of the conical mirror, the return cone being mounted mobile or non-mobile along the axis of the conical mirror.

According to one characteristic of embodiment, the optical converging system
5 for the ring of light is a lens of Fresnel type..

According to another characteristic of embodiment, the illumination device comprises a light diffuser placed between the optical focusing system and the annular light sources.

According to another characteristic of the invention, the illumination device
10 comprises a polarizer placed between the illumination system and the container in order to polarize the incident light beam, and a polarizer positioned so that it can filter the reflected light beam.

According to a further characteristic of embodiment the illumination system, at the centre of its ring of light of variable diameter, comprises a sighting zone for a
15 camera.

According to a further characteristic of embodiment the illumination system, in the camera's sighting zone, comprises a semi-reflective optical element able to transmit an additional flow of light in direction of the container to be inspected and to ensure transmission to the camera of the light beam reflected by the container.

20 A further objective of the invention is to propose a station for detecting surface defects and/or material shortage on the neck ring of a container having an axis of symmetry. Said detection station comprises :

- an illumination device of the invention,
- a line scan camera positioned to receive the light beam reflected by the
25 neck ring of the container,
- and a processing and analysis unit connected to the camera and adapted to analyse the video signal delivered by the camera in order to determine the presence of a surface defect and/or material shortage.

Various other characteristics will become apparent from the following
30 description with reference to the appended drawings given as non-restrictive examples and showing embodiments of the subject of the invention.

Fig. 1 is an elevation schematic showing the implementation of the method of the invention using a first variant of embodiment of the illumination device.

Fig. 2 is a schematic explaining the principle of the illumination method of the invention.

Fig. 3 is an overhead view of an example of embodiment of an illumination source used by the illumination device of the invention.

5 **Fig. 4** is an example of an image obtained using the method of the invention.

Fig. 5 is a schematic elevation view of a second variant of embodiment of an illumination device of the invention.

Fig. 6 illustrates a variant of embodiment of the second embodiment illustrated in **fig. 5**.

10 **Fig. 7** illustrates a further characteristic of the illumination device of the invention.

Fig. 1 illustrates an illumination device **1** of the invention for a surface defect and/or material shortage detection station **2** to detect possible defects on surface **s** of the neck ring **3** of a container **4** that is transparent or translucent for example and has an axis of symmetry or of revolution **X**.

15 In conventional manner, said detection **2** comprises a line scan camera **6**, positioned to collect the light beam reflected by the surface **s** of the neck ring **3** of the container **4**. This camera **6** is connected to an processing and analysis unit **7**, adapted to analyse the video signal delivered by the camera, in order to determine the presence of a surface defect and/or material shortage on neck ring **3**. The processing and analysis unit **7** will not be described in more detail since it does not come under the subject of the invention and is part of the general knowledge of persons skilled in the art.

20 Said detection station **2** comprising the illumination device **1** of the invention can be used to apply an optical detection method for detecting surface defects and/or material shortage on the surface of neck ring **3**.

30 According to the invention, the illumination device **1**, as can be seen more precisely in **figs. 1** and **2**, comprises illumination means **9** able to provide a uniform, convergent ring of light **C** converging towards a point of convergence **F** located on the axis of symmetry **X** of container **4** and having a variable diameter **D** and a variable width or expanse **E**. In the example of embodiment illustrated **figs. 1** and **3**, the illumination means **9** comprise an illumination system **11** able to provide a ring of light **12**, of variable diameter **D** and/or variable expanse or width **E**. In the variant

of embodiment, illustrated **figs. 1** and **3**, the illumination system **11** consists of a series of elementary annular light sources **14**, totalling ten in the illustrated example, mounted concentric fashion with respect to one another, allowing a sighting zone **Z** to subsist in the centre for camera **6**. These elementary annular light sources **14** may
 5 be tubes, fibre optic rings, or unit sources, such as electroluminescent diodes, arranged in concentric rings as illustrated **fig. 3**. Each elementary annular light source **14** is therefore able to provide an elementary ring of light of given width that is identical or different to the width of the other elementary annular rings of light, and extending adjacent to one or two other elementary rings in relation to their
 10 position.

According to a preferred characteristic of embodiment, the illumination system **11** comprises a light diffuser **15** placed in front of the elementary annular sources **14**, so as to obtain a uniform ring of light **12** of width or expanse **E**, formed from one or more elementary rings, preferably neighbouring rings. It is to be noted that **fig. 1**
 15 only shows the mean elementary light rays provided by sources **14**.

According to the variant illustrated in the drawings, the illumination means **9** also comprise an optic system **16** for converging or focusing the uniform ring of light **12** onto a point of convergence **F**, located on the axis of symmetry **X** of the container, so as to illuminate the surface **s** of the neck ring **3** of the container with a
 20 uniform convergent light beam **C**. According to a preferred variant of embodiment, the optical focusing system **16** is a lens of Fresnel type. As shown in **fig. 1**, the light diffuser **15** is interposed between the Fresnel **16** lens and the elementary annular sources **14**.

Each uniform, convergent light beam **C** derived from the uniform ring of light
 25 **12**, is therefore delimited between two light cones **19** and **20** having the same apex, point of convergence or focus **F**. This convergent light beam **C** therefore has a mean angle of incidence α which takes into account the mean ray of convergent beam **C**. Each light cone **19**, **20**, respectively delimiting the convergent light beam **C** inwardly and outwardly, therefore has a different angle of incidence α . It is to be noted that the
 30 angle of incidence α for the convergent light beam **C** may lie between 0 to 60° for example, preferably between 0 and 45°.

The illumination device 1 of the invention also comprises means 22 for creating a convergent, uniform ring of light C having a given diameter value D with respect to the desired mean angle of incidence α to illuminate the surface s of the neck ring 3 and/or a given expanse value E in relation to the width L of surface s of the neck ring of the container. In the example of embodiment illustrated **figs. 1 and 3**, the means 22 for creating a convergent ring of light C are formed by a selective on/off command unit for elementary light sources 14. This command unit 22 is used to selectively pilot the on/off operation of the elementary light sources 14, so as to select:

- 10 ▪ the diameter D of the ring of light 12 and subsequently the mean angle of incidence α of the convergent light beam C,
- and/or the width E of said beam in relation to the number of annular light sources 14 that are switched on.

In relation to the position of the elementary light source or sources that are switched on, an angle of incidence α of different values may be obtained. Similarly, provision may be made to simultaneously command the switching-on of one or more elementary light sources 14, that lie next to each other so as to act on the width or expanse E of the ring of light 12 and hence of the focused light beam C. In the example illustrated **fig. 1**, the four elementary annular sources the closest to the periphery are switched on while the other sources 14 are switched off.

With said illumination device 1 it is therefore possible to obtain a convergent ring of light C with an adjustable mean angle of incidence α and/or an adjustable width E. Said adjustable angle of incidence for illumination makes it possible to adapt to the slope of neck rings 3. The width E of the convergent ring of light C enables uniform illumination to be obtained over the entire surface of the neck ring 3 of the container, irrespective of the diameter of the neck ring and the width L of the surface s of the neck ring. It is to be noted that the convergent ring of light C at the surface s of neck ring 3, has a width I that is equal to or greater than the width L of surface s of the neck ring.

30 It is to be noted that container 4 may be moved along its axis of symmetry X, in order to adjust the position of surface s of the neck ring with respect to the convergent light beam C.

According to an advantageous characteristic of embodiment, the illumination device **1** comprises a polarizer, not shown, interposed between the illumination system **11** and the container **4**, in order to polarize the incident light beam **C**. Preferably, the light beam **C** is polarized circularly by a circular polarizer mounted
 5 between the Fresnel lens **16** and the container **4**. A polarizer, of same circular type as the one used for the incident beam, is placed in front of the lens of camera **6** to filter the reflected light beam. The light, reflected on the surface of neck ring **3**, is not depolarized and therefore passes without being attenuated through the polarizer placed in front of the lens of camera **6**. On the other hand, stray light which has
 10 undergone multiple reflections inside container **4** is partly depolarized and is hence attenuated when passing through the polarizer placed in front of the camera. Said polarization makes it possible to attenuate stray light with respect to the incident illumination light.

As can be clearly seen **fig. 1**, the illumination means **9**, in the centre of their
 15 ring of light **12**, comprise a sighting zone **Z** for camera **6**. This sighting zone **2** is arranged in the centre of the illumination system **1** which in this zone does not comprise elementary annular light sources **14**. For example, this sighting zone **Z** may be occupied by a divergent lens **35** forming a first image **36** of the neck ring **3** taken up by a variable focus system **6₁** such as a short focusing zoom, associated with the
 20 camera **6**.

The illumination device **1** of the invention is particularly adapted to allow detection of defects on the surface **s** of neck rings of containers, in particular unfilled finishes through material shortage. As can be seen **fig. 4**, the flow of light **37** reflected by the surface **s** of a neck ring gives a ring of light **A1** which, when there is
 25 a material shortage defect on the surface of neck ring **3**, has a dark area **B** corresponding to the defect.

It is to be considered that any defect occurring on surface **s** causes either lack of light or local concentration of light translating as a dark spot flare that is detectable by the processing and analysis unit **7**.

Fig. 5 illustrates a second variant of embodiment of the illumination system **11**
 30 providing a uniform ring of light **12** of variable diameter. According to this variant, the illumination system **11** consists of a conical mirror **40** which in the illustrated example has a polished inner surface. The illumination system **11** also comprises a

planar annular light source **41** emitting onto the conical mirror and more precisely onto the polished inner surface, perpendicular to axis **A** of the conical mirror **40** which is co-linear with the axis of symmetry **X** of the container. The conical mirror **40** and the annular light source **41** are movably mounted with respect to one another
 5 along axis **A** of the conical mirror **40**.

According to this variant of embodiment, the means **22** for creating a ring of light **12** of given diameter are formed by command means commanding the relative movement of the conical mirror **40** and the planar annular light source **41**. These command means **22** ensure the relative movement of the conical mirror **40** and the
 10 planar annular light source **41** along axis **A** of the conical mirror **41** and over a given height in order to obtain a ring of light **12** of determined diameter. Evidently, provision may be made to move either the conical mirror **40**, or the light source **41** or both.

In the illustrated example of embodiment, the planar light source **41** may be
 15 made in different manners, for example using an optic fibre, bulb, fluorescent tube, electroluminescent diodes, etc. Also, the annular light beam, as explained in the example illustrated **fig. 1**, is directed towards the light diffuser **15** and the Fresnel lens **16**.

Fig. 6 illustrates another variant of embodiment, in which the planar annular
 20 light source **41** consists of an annular light source **44**, emitting along a direction substantially parallel to axis **A** of conical mirror **40**, in the direction of a return cone **45** returning the light beam in a direction perpendicular to the axis of conical mirror **40**. The return cone **45** may be mounted mobile fashion in relation to the conical mirror so as to obtain a ring of light **12** of variable diameter. Evidently, provision
 25 may also be made to mount the return cone **45** in fixed manner, while the conical mirror **40** is movably mounted as explained above.

It is to be noted that in the examples of embodiment illustrated **figs. 5** and **6**, the light source **41**, **44** emits onto the inner surface of a conical mirror **40**. Evidently, it may be contemplated that the light source sends its beam onto the outer polished
 30 surface of the conical mirror **41**, reversing the direction of the conical mirror **40**.

It is to be noted that the assembly illustrated **fig. 6** also makes it possible to adjust the expanse **E** of the ring of light **12**. Insofar as the annular light source **44** is divergent, (for example at an angle of 60° for an optic fibre) , expanse **E** of the ring

of light 12 projected onto the light diffuser 15 varies when the length of the optic pathway of the light rays is modified between source 44 and diffuser 15, passing through the return cone 45 and the conical mirror 40. Said modification of the optic pathway of the light rays may be obtained by moving source 44 along axis A of the mirror.

Fig. 7 illustrates a preferred variant of embodiment of the illumination device 1 in which provision is made to produce additional illumination with rays parallel or almost parallel to axis X of the container having regard to the presence of the sighting zone Z for camera 6. This sighting zone Z, located in the centre of the illumination means 9, does not make it possible to obtain light rays with corresponding angles of incidence. According to this variant of embodiment, an additional light beam is provided in this sighting zone Z, in order to obtain angles of incidence that are complementary with respect to those obtained with the uniform ring of light 12.

According to this example of embodiment, the illumination system 11 in its sighting zone Z, comprises a semi-reflective optical element 50, such as a semi-reflective strip able to transmit an additional flow of light along a direction parallel to axis X in the direction of container 4, and derived from an additional light source 51. The semi-reflective optical element 50 enables the transmission to camera 6 of the light beam 37 reflected by container 4.

The invention is not limited to the examples shown and described since various modifications may be made thereto without departing from the scope of the invention.